PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

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Applicant's or agent's file reference	FOR FURTHER ACTION	See Form PCT/IPEA/416
214165/EP/he		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/NL2004/000922	29.12.2004	30.12.2003

International Patent Classification (IPC) or national classification and IPC
B23K26/067, B23K26/08, B23K26/38, H01L21/78, H01L21/304, G02B27/10, G02B27/42, G02B3/00, G02B3/08, B23K26/00

Applicant
ADVANCED LASER SEPARATION INTERNATIONAL... et al.

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 6 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *sent to the applicant and to the International Bureau)* a total of 6 sheets, as follows:
      ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

☒	Box No. I	Basis of the opinion
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

Date of submission of the demand	Date of completion of this report
31.10.2005	06.03.2006
Name and mailing address of the international preliminary examining authority:	Authorized Officer
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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/NL2004/000922

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
   - ☐ international search (under Rules 12.3 and 23.1(b))
   - ☐ publication of the international application (under Rule 12.4)
   - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages

1-3, 6, 7, 9-13	as originally filed
4, 5, 8	received on 01.11.2005 with letter of 31.10.2005

Claims, Numbers

1-13	received on 01.11.2005 with letter of 31.10.2005

Drawings, Sheets

1-3	as originally filed

☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

* *If item 4 applies, some or all of these sheets may be marked "superseded."*

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/NL2004/000922

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-13
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-10
	No:	Claims	11-13
Industrial applicability (IA)	Yes:	Claims	1-13
	No:	Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

V.1 Cited documents

The following documents (D) are referred to in this communication ; the numbering will be adhered to in the rest of the procedure :

D1: US-B1-6 635 849 (T. OKAWA ET AL) 21 October 2003 (2003-10-21)
D2: WO 01/37769 A (Y. AMITAI ; B. SHALEV AND AL) 31 May 2001 (2001-05-31)
D3: US-A-5 633 735 (R.O. HUNTER JR ET AL) 27 May 1997 (1997-05-27)
D4: US-A-5 029 243 (H. DAMMAN ET AL) 2 July 1991 (1991-07-02)
D5: US-A-5 922 224 (J.C.E. BROEKROELOFS) 13 July 1999 (1999-07-13)
D6: EP-A-0 679 469 (MITSUBISHI ELECTRIC CORP) 2 November 1995 (1995-11-02)
D7: WO 02/094528 A (KULICKE & SOFFA INVESTMENTS ; R. MANOR) 28 November 2002 (2002-11-28)

V.2 Claims 1-9

D5, which is considered to represent the most relevant state of the art, discloses (Figures 1 and 4 with corresponding passages of the description) a method of separating semiconductor elements (4) on a substrate (1) from which the subject-matter of claim 1 differs by the features and steps defined in the characterising portion of claim 1.

The integration of two different grating orientations in one grating allows a higher precision during the separation of semi conductors elements, in particular during the change of direction of the cutting. After the scoring in one direction using the first diffracting region of the grating, the scoring in the second direction is achieved by moving the grating so that the laser beam impinges on the second diffracting region of the grating. A minimum error level is then introduced during this moving step in comparison with the rotation of the substrate mount. The problem to be solved by the

present invention may therefore be regarded as to provide a method of separating semi conductors elements on a substrate with a higher precision cutting.

The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reasons :

a- no indication could be found in D5 in order to use a diffracting grating with two different zones so that the cut is of higher precision. D1 describes the use of a stack unit for stocking several diffracting gratings, all of them having only one diffracting zone with a unique grating structure. D2 describes the use of a multi grating plates holding structure, wherein a plurality of different gratings are integrated in it. Each grating has also only one grating structure. The change of grating direction is achieved by displacing the grating holding means. In D2, no precise orientation means is provided between each grating in order to insure a high precision cutting, i.e. the gratings are susceptible to move relative to each other (due to vibrations, reduced tightening load between the holding means and the gratings, ...) during the machining step. D3 describes the use of Fresnel Zone Plate having two different grating structures. D4 describes also the use of a gratings supporting/holding means so that a diffracting direction could be easily changed during machining

b- no indication is given in D2, D4 or D6 (also using a multiple grating holding structure) for using a single grating having two different grating structures

Claims 2-6 are dependent on claim 1 and as such also meet the requirements of the PCT with respect to novelty and inventive step (Article 33 (2-3) PCT).

V.3 Claims 7-10

D5, which is considered to represent the most relevant state of the art and to correspond to the prior art known by the applicant on which the preamble of claim 10 is constructed (see Item V.2), discloses (Figures 1 and 4 with corresponding passages of the description) an apparatus for separating semiconductor elements (4) formed on a substrate (1) from which the subject-matter of claim 10 differs by the features of the apparatus defined in the characterising portion of claim 7.

The problem to be solved by the present invention may therefore be regarded as to provide a method of separating semi conductors elements on a substrate with a higher precision cutting. The solution to this problem proposed in claim 7 of the present application is considered as involving an inventive step (Article 33(3) PCT) by following the same argumentation as the one detailed for claim 1 (see Item V.2).

Claims 8-10 are dependent on claim 7 and as such also meet the requirements of the PCT with respect to novelty and inventive step (Article 33 (2-3) PCT).

V.4 Claims 11-13

Either D2 or D6 discloses (the references in parentheses applying to this document) a diffraction grating (Figure 8) suitable for using in a method according to claim 1 (for example), from which the subject-matter of claim 11 differs in that the diffraction grating has a second part having a second grating structure.

This avoids the construction of different grating parts which have to be mounted in a grating holding structure. This allows also the provision of a compacter grating structure comprising several diffracting directions. However, the integration of different grating structures on a same plate has already been employed for the same purpose in a similar grating plates, see document D3 (Figure 2). Indeed, in D3, in order to create different hole patterns onto a substrate, a Fresnel Zone Plate (Figure 2 again), having at least two different zones, is provided. It would be obvious to the person skilled in the art, namely when the same result is to be achieved, to apply these features with corresponding effect to a diffraction grating according to document D2 thereby arriving at a diffraction grating according to claim 11.

Dependent claims 12-13 do not appear to contain any additional features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT with respect to novelty and/or inventive step (Article 33 (2-3) PCT) ; see D2 for claims 12-13 ; see D6 for claims 12-13.

CLAIMS

(100)

1. Method of separating semiconductor elements on a substrate, such as semiconductor elements formed in a wafer of semiconductor material, using a laser producing at least one primary laser beam, wherein said at least one primary laser beam is split into a plurality of secondary laser beams using a first diffraction grating having at least a first grating structure and by impinging said at least one primary laser beam on said first grating structure, and wherein at least one first score is formed by moving said laser relative to said substrate in a first direction, said method further comprising a step of forming at least one second score by moving said laser relative to said substrate in a second direction, characterised in that, said second grating structure is comprised by said first diffraction grating, and before said step of moving said laser relative to said substrate in said second direction, said method comprises a step of altering said first grating structure to a second grating structure, by moving said first diffraction grating such that said at least one primary laser beam impinges on said second grating structure.

2. Method according to claim 1, wherein said step of moving said first grating structure comprises translating said first diffraction grating.

3. Method according to any of the previous claims, wherein said first and second grating structures are chosen such that said second grating structure is a mathematical image of said first grating structure by rotating said first grating structure over a rotation angle.

4. Method according to claim 3, as dependent on claim 1, wherein said step of altering said first grating structure comprises rotating said first diffraction grating for forming said second grating structure.

5. Method according to claim 4, wherein said step of rotating

said first diffraction grating comprises rotating relative to an axis of rotation transverse to said at least one primary laser beam.

6. Method according to any of the previous claims, wherein said second direction is transverse to said first direction.

7. Device for separating semiconductor elements formed on a substrate, such as semiconductor elements formed in a wafer of semiconductor material, comprising a laser arranged for producing at least one primary laser beam, a first diffraction grating having at least a first grating structure, said first diffraction grating arranged for splitting said at least one primary laser beam into a plurality secondary laser beams by impinging said at least one primary laser beam onto said first grating structure, means arranged for moving said substrate relative to said laser in at least a first direction for forming a first score, said means arranged for moving being further arranged for moving said substrate relative to said laser a second direction for forming a second score, characterised in that, said second grating structure is comprised by said first diffraction grating, and said device further comprises means arranged for altering said first grating structure to a second grating structure, by moving said first diffraction grating such that said at least one primary laser beam impinges on said second grating structure.

8. Device according to claim 7, wherein said means arranged for altering said first grating structure are arranged for translating said diffraction grating relative to said at least one primary laser beam.

9. Device according to any of the claims 7 or 8, wherein said second grating structure is a mathematical image of said first grating structure by rotating said first grating structure over an angle of rotation.

10. Device according to claim 9, wherein said means arranged for moving said first grating structure are arranged for rotating said

first diffraction grating around an axis of rotation transverse to said at least one primary laser beam.

11. Diffraction grating for use in a method according to any of the claims 1-6, said diffraction grating comprising a first part having a first grating structure and a second part having a second grating structure.

12. Diffraction grating according to claim 11, wherein said second grating structure is a mathematical image of said first grating structure by rotating said first grating structure over an angle of rotation.

13. Diffraction grating according to claim 12, wherein said rotation angle is a straight angle.

deviation will grow over the distance travelled by the laser relative to the wafer.

In industry this may be anticipated by providing a so called scribing lane, which is a region in between each of the rows and columns of semiconductor elements formed on the wafer, wherein the score may be formed. A variation in the cutting direction will not directly result in the loss of semiconductor elements if the scribing lane is chosen to be broad enough. However, the dimensions of the scribing lane (broadness) determines to some extend the number semiconductor elements that can be formed on the surface of the wafer. As will be appreciated, the scribing lanes must therefore be as small as possible. It will therefore be understood that a lot of effort is put in accurate rotation of the wafer, such that the variations in rotation angle are as small as possible. This slows down the separation process.

Another disadvantage is that the pattern of focal points and the orientation of the secondary laser beams relative to the wafer surface is determined by the characteristics of the diffraction grating. It is therefore not possible to amend this pattern during the process without interrupting the process and replacing the diffraction grating.

Summary of the invention

It is an object of the present invention to provide a method for separating semiconductor elements, which alleviates the abovementioned problems, which enables accurately forming scores in either direction and which enables amending the pattern of focal points of secondary laser beams during the process.

This is achieved by the present invention by providing a method according to claim 1.

By altering the first grating structure to a second grating structure for use in the second direction, it is no longer required to use the same diffraction grating structure for both the first and the

second direction. Therefore, a suitable direction grating structure may be used for the first direction and another suitable grating structure may be used for the second direction; each of the first and second grating structures adapted to the requirements of the direction wherein they are used. The second grating structure may, for instance, simply be a rotated mathematical image of the first grating structure, or may alternatively be a completely different grating structure. This enables moving the wafer (or the laser) in a different direction (e.g. sideways instead of back and forth), without having to rotate the wafer relative to the laser first and without having to replace the diffraction grating. Variations in the rotation angle and/or cutting direction caused by rotation of any element relative to any other element in the process are thereby anticipated. The scores to be formed in the wafer dicing method may therefore be placed more accurate, and the required scribing lanes can be made smaller than in conventional wafer dicing methods. As a result, the density of semiconductor elements on the wafer surface may be increased, which reduces the costs of production.

The method may be applied to method for separating

perpendicular to the lines of the first grating structure in the plane which is perpendicular to the primary laser beam.

It will be appreciated that another possibility for altering the first grating structure to the second grating structure comprises rotating said first diffraction grating relative to an axis of rotation parallel to said primary laser beam. Said rotation should be performed accurately over the desired angle of rotation.

According to a second aspect the present invention provides a device for separating semiconductor elements formed on a substrate, in accordance with claim 8.

In the third aspect of the present invention there is provided a diffraction grating in accordance with claim 12.

The present invention will now further be elucidated by a description and drawings referring to preferred embodiments thereof, directed to a method and arrangement for separating a semiconductor element formed on the surface of a wafer, wherein the semiconductor elements are distributed over the wafer in a matrix distribution, such